PB-217 054

OHIO RIVER POLLUTION CONTROL

M. LeBosquet, Jr.

Public Health Service
Cincinnati, Ohio

1944

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Federal Security Agency
U. S. PUBLIC HEALTH SERVICE
Water & Sanitation Investigations Station
Cincinnati, Ohio

OHIO RIVER POLLUTION CONTROL

M. LeBosquet, Jr.
Principal Public Health Engineer

(Delivered before the Delegates of the Ohio River Valley Water Sanitation Compact, December 7, 1944, Pittsburgh, Pa.)

Mr. Chairman, Delegates of the
Ohio River Valley, and Guests:

I greatly appreciate the opportunity of discussing the pollution problems of the Ohio River and its tributaries with you today. The information collected during the course of the Ohio River Pollution Survey has been turned over to the States as the survey proceeded. When the Ohio River Valley Water Sanitation Compact becomes a working reality, the U. S. Public Health Service, I am sure, will be glad to make the vast fund of collected information available to this body.

Before me I have a summary of the data, in a copy of the final report on the Ohio River Pollution Survey. It is entitled "Ohio River Pollution Control" and is House Document 266 of the 78th Congress, 1st Session. The report has 1500 pages, is in three volumes weighing 6 pounds, and was prepared at a cost of $600,000.

The Federal legislation initiating the activity directed the Secretary of War to conduct the survey. The President suggested that an Ohio River Committee be appointed to supervise the work. Under this Committee, the U. S. Public Health Service was called upon for assistance which involved the following activities:

1. Locate all important sources of pollution,
2. Ascertain the amount of polluting material discharged at each,
3. Measure the present effects of the wastes on the streams by means of physical, chemical, bacteriological and biological examinations,
4. Determine present and prospective uses of streams.
5. Estimate the effects of changes in stream flows and river conditions and of possible future additional pollution.
6. Determine the degree of pollution abatement, by treatment, low-flow regulation, or other methods which seem economically justified in the light of present and prospective stream uses.
7. Determine water quality requirements for various uses.

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8. Determine available techniques for correcting various types of pollution and their cost.

9. Investigate disease outbreaks suspected of being waterborne.

10. Study legal and administrative instruments and methods available for effecting pollution abatement.

11. Prepare a comprehensive pollution abatement program including estimates of cost.

12. Prepare a report.

All hydrometric studies were carried out by the Corps of Engineers. This and other work included the following items:

1. Measure or estimate flows at sampling stations on sampling days.

2. Tabulate monthly summer flows of record at all gaging stations and prepare low-flow frequency curves.

3. Conduct studies of times of flow.

4. Study possible modifications of low flows by proposed reservoirs.

5. Prepare first draft of Ohio River Committee report.

In attempting to give you an idea of the results of the survey, it will be necessary for me to confine myself to the high spots. I will give you a general idea of the magnitude of the survey, and then I plan to give you summarized information on sources of pollution, including sewage and industrial wastes, and acid mine drainage as a special type of industrial wastes. I will mention briefly the possibilities of assisting pollution abatement measures by increasing low flows and will describe critical pollution problems in six metropolitan areas on the main stream and tributaries. I will then conclude with a brief discussion of the all-important question of the costs of a pollution abatement program.

DESCRIPTION OF SURVEY

Figure 1 is a map of the Ohio River Basin covering parts of 14 states, including such distant states as Mississippi and Alabama. The Ohio River Basin covers an area of 204,000 square miles having a population of 19,000,000. During the Ohio River Pollution Survey, information was collected concerning the pollution from 3700 municipalities and 1800 industries. A tremendous laboratory program was carried out, during which 71,000 samples were collected from 2,000 sampling points. A total of 131,000 individual determinations was made. Information was collected during a period of three years, and, at the time of maximum activity, almost a hundred people were employed.

SOURCES OF POLLUTION

Figure 2 shows the location and magnitude of the principal sources of organic wastes, including both sewage and industrial wastes. The areas of the circles

represent pollution loads in terms of sewered population equivalent based on biochemical oxygen demand or organic pollution constituents. This is only one measure of the magnitude of pollution, as it does not reflect taste- and odor-causing substances, inorganic or acid characteristics, or toxic substances. However, it is probably the most important single measure of pollution.

In certain cases the shaded circle is surrounded by an unshaded area within an outer circle. This unshaded area represents the pollution which has been removed by a municipal sewage treatment plant.

It will be noted that there are four large circles representing the pollution from metropolitan areas, namely at Pittsburgh, Pa., Charleston, W. Va., Cincinnati, Ohio, and Louisville, Ky. Although the Pittsburgh area has a somewhat greater population than the Cincinnati area, the pollution loads are comparable, due to larger discharges of organic industrial wastes at Cincinnati. The Charleston W. Va., area is particularly notable in respect to industrial wastes, in that sewage comprises a small portion of the total pollution load. Lesser but important pollution loads are also shown at Youngstown, Ohio, Terre Haute, Ind., and several points on the Tennessee and Cumberland Rivers in the southern portion of the basin.

Municipal Sewage. Important sewage treatment plants can be readily seen on the map at Canton, Columbus and Dayton, Ohio, and Indianapolis, Ind. The map brings out rather strikingly the fact that the 464 sewage treatment plants in the basin are largely at the smaller places and away from the Ohio River. In 1900, treatment plants were in operation only at Alliance and Canton, Ohio. Treatment has been continuous since that time and modern plants now serve these two cities.

Table 1 summarizes the situation in the Ohio River Basin as regards municipal sewage treatment. It is noted that in the 14 Ohio River Basin states the per cent of sewage which is treated is 57 considering the states as a whole, but is only 34 when considering only those portions of the states which lie in the Ohio River Valley. It would appear that less progress has been made in the Ohio River Valley than in the Ohio River states as a whole and also in the country. This seeming discrimination against the Ohio River Valley is true in all the states with the exception of New York, Tennessee and Virginia. This table is not meant to reflect any intent of the states to discriminate against the Ohio River Valley, but it does indicate the difficulties of correcting pollution in an interstate stream and lack of incentive to correct pollution in acid streams. For example, in Pennsylvania only 17 per cent of the sewage is treated, while an examination of the data from the Beaver River Basin indicates that every community in this basin in Pennsylvania, with the exception of New Brighton, now has a sewage treatment plant, and New Brighton is considered an Ohio River pollution problem rather than a Beaver River pollution problem.

Industrial Wastes. Table 2 presents a summary of the industrial waste pollution in the Ohio River Basin and shows that this pollution load has a sewered population equivalent of nearly 10,000,000 prior to treatment of part of these wastes in municipal sewage treatment plants. Inasmuch as the total sewered population is 8,500,000, it is apparent that the industrial pollution load is greater than the domestic pollution load. Also, as against 34 per cent of municipal sewage discharging to municipal treatment plants, only 12 per cent of industrial wastes is now discharged to municipal sewage treatment plants.

OHIO BASIN
LAKE ERIE
N. Y.
PENNA.
OHIO
ILLINOIS
INDIANA
MD.
W. VA.
VIRGINIA
KENTUCKY
MO.
TENNESSEE
N. C.
S. CAR.
MISS.
ALA.
GEORGIA
ST. LOUIS
CLEVELAND
TOLEDO
SOUTH BEND
PITTSBURGH
FIG.-1
LEGEND
U.S. ENGINEER DEPARTMENT DISTRICTS
DISTRICT BOUNDARY
NAVIGATION DAM
DISTRICT HEADQUARTERS
SCALE OF MILES
OHIO RIVER POLLUTION SURVEY
U. S. PUBLIC HEALTH SERVICE
MARCH 1942

Fig.-1

Table 1 - Status of Municipal Sewage Treatment -
Ohio River Valley

(Populations in Thousands)

State	Entire State			Ohio River Valley		
	Population connected to		Per cent treated	Population connected to		Per cent treated
	Sewers	Treatment		Sewers	Treatment	
Illinois	5,580	5,202	93	203	150	74
Indiana	1,736	1,166	67	1,164	724	62
Kentucky	851	220	26	849	199	23
New York	9,801	5,992	61	111	81	73
Ohio	4,611	2,983	65	2,594	1,214	47
Pennsylvania	6,471	1,693	26	2,187	360	17
Tennessee	829	135	16	553	101	18
Virginia	852	181	21	59	14	24
West Virginia	677	68	10	664	55	8
Other (1)	4,001	2,588	65	177	15	8
Total	35,409	20,228	57	8,561	2,913	34
U. S. A.	70,864	42,155	59	70,864	42,155	59

(1) Alabama, North Carolina, Georgia, Maryland, Mississippi.

Table 2 - Ohio River Basin - Summary Showing Industrial Wastes Not Discharging to Municipal Treatment Plants, Suggested Industrial Waste Discharges to Municipal Treatment Plants and Total of Entire Industrial Waste Load in the Basin.

Industry		Number of plants	Industrial waste disposal		At least minor corrective measures taken	Estimated sewered population equivalent (B.O.D.)	Suggested to municipal treatment	
			Munic. sewers	Private outlets			Number of plants	Population equivalent (B.O.D.)
Brewing	See Note (1)	38	35	3	27	264,300	37	263,800
By-Product Coke		23	2	21	17	745,200	2	24,300
Canning		218	52	166	160	758,900	64	310,300
Chemical		65	10	55	36	1,880,400	8	138,000
Distilling		67	14	53	53	1,009,700	20	624,600
Meat		173	76	97	115	385,700	123	323,900
Milk		253	130	123	107	85,100	167	74,700
Oil Refining		47	4	43	44	116,500	2	15,100
Paper		59	12	47	46	1,659,200	5	31,500
Steel		174	15	159	71	(2)	12	0
Tanning		32	5	27	13	269,600	13	55,400
Textile		122	57	65	10	335,100	84	216,900
Miscellaneous		333	104	229	109	160,300	89	132,500
Total		1,604	516	1,088	808	7,670,000	626	2,211,000
Industrial Wastes to Cincinnati Sewers (3)						1,108,400	-	1,108,400
Wastes Discharged to Municipal Treatment						1,195,900	-	-
Totals for the Basin						9,974,300	626	3,319,400

(1) Note; Industries occurring only once in a basin are included under "Miscellaneous" in the basin summary but are under their proper classification in this table.

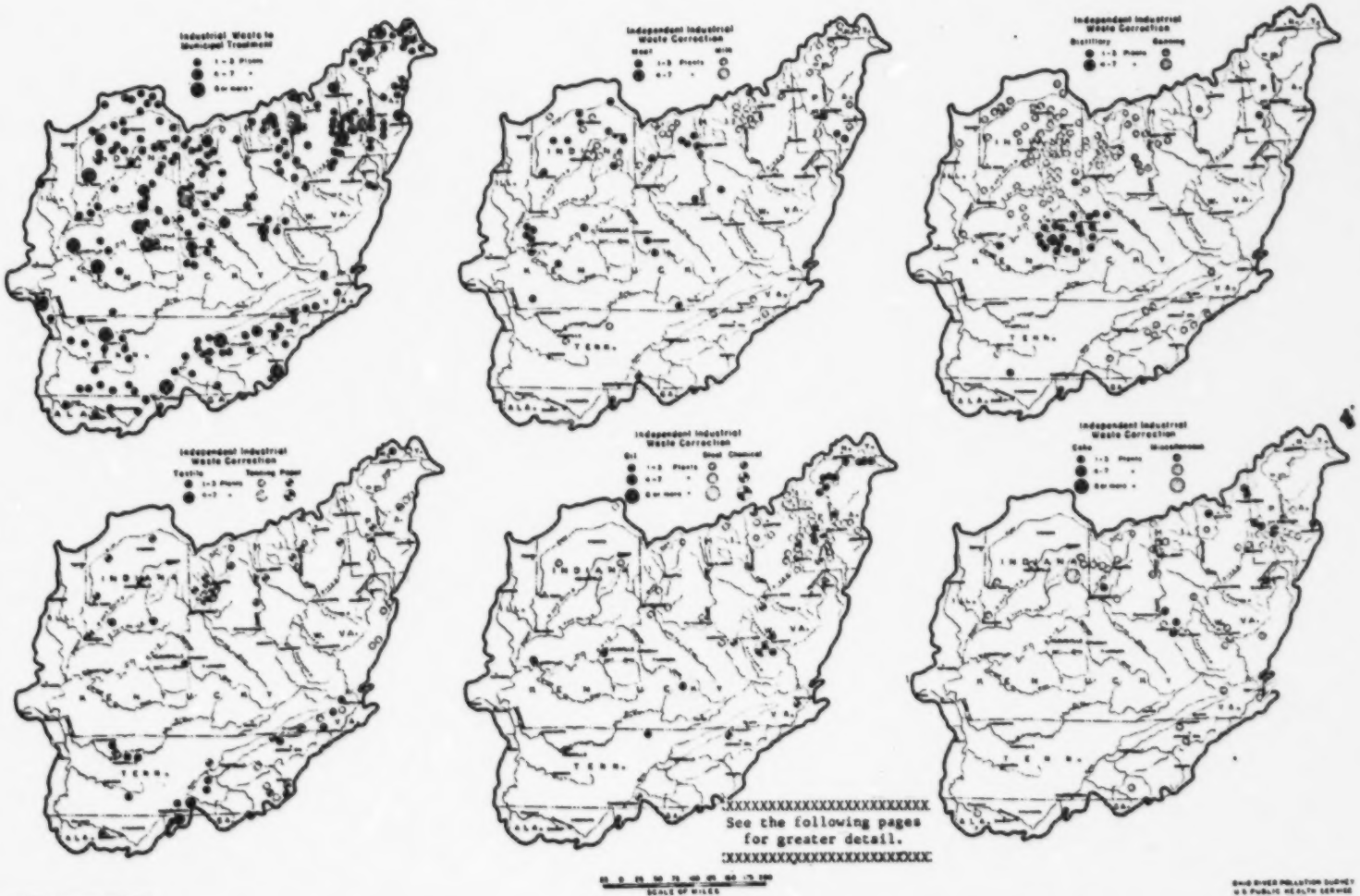
(2) 336,000 pounds free acid discharged daily in waste pickle liquor.

(3) Industries not surveyed individually. Population equivalent based on comprehensive sewer gaging and sampling program of city. (Table 3, page 167, H.R.266, 78-1).

Fig. 3

OHIO RIVER BASIN

SUGGESTED INDUSTRIAL WASTE CORRECTION



6.1 ✓

Fig. 2

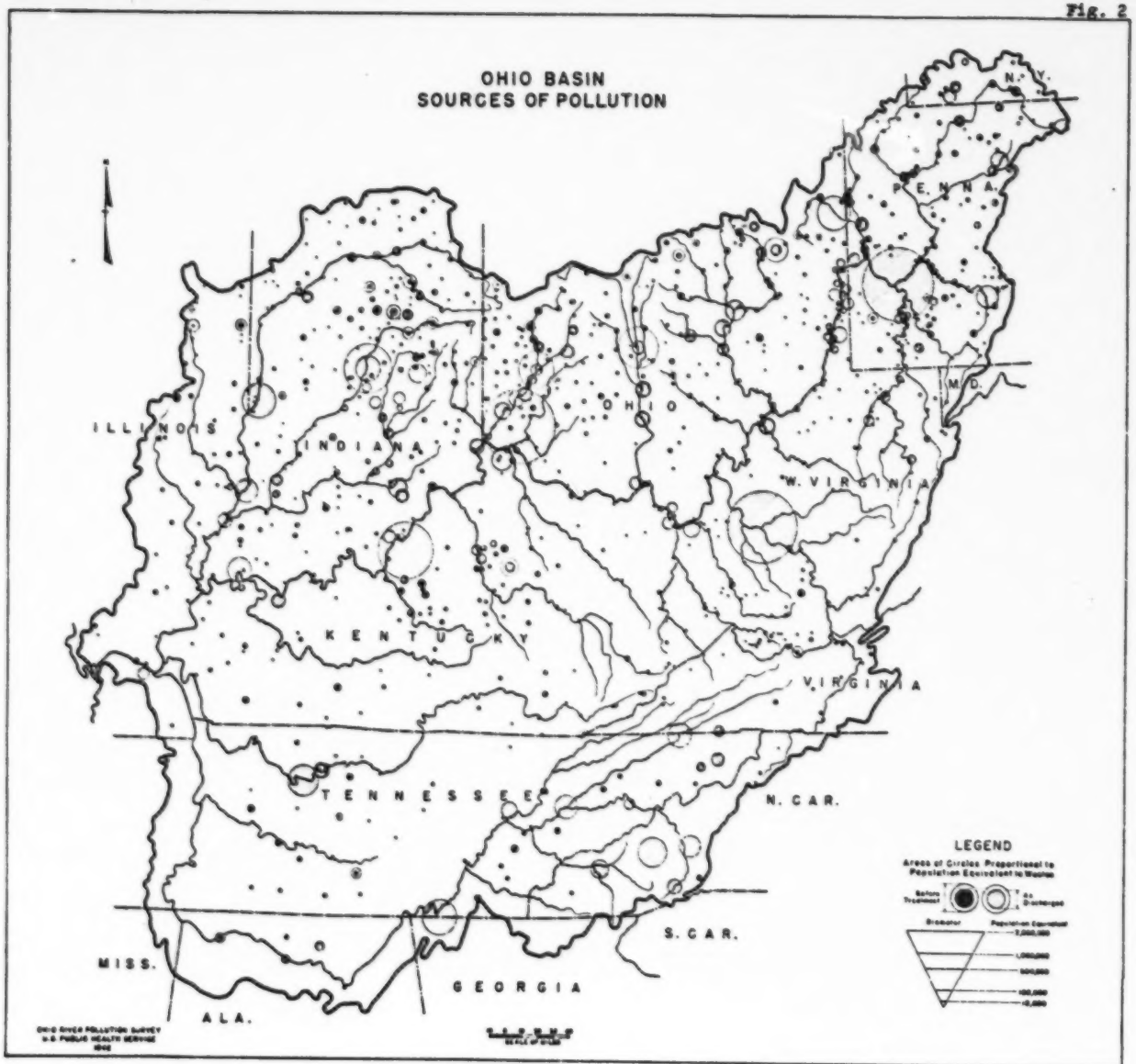

OHIO BASIN
SOURCES OF POLLUTION
N. Y.
PENNA.
MD.
OHIO
ILLINOIS
INDIANA
W. VIRGINIA
KENTUCKY
VIRGINIA
TENNESSEE
N. CAR.
S. CAR.
MISS.
GEORGIA
ALA.
LEGEND

Fig. 3

OHIO RIVER BASIN

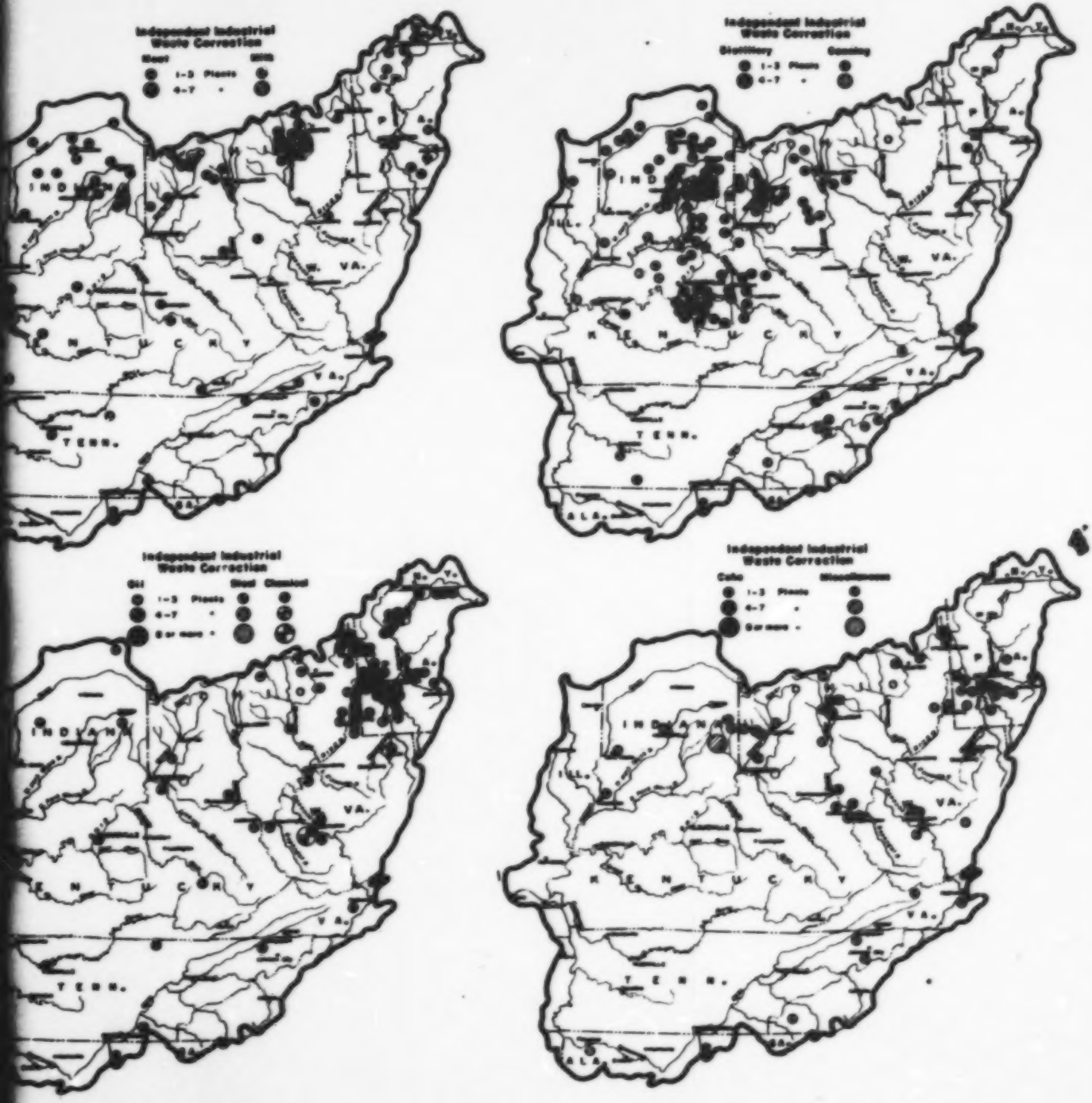
SUGGESTED INDUSTRIAL WASTE CO

NOTE:- Exclusive of plants where present corrective measures are adequate

SCALE OF MILES

6d 2

Fig. 3
OHIO RIVER BASIN
TED INDUSTRIAL WASTE CORRECTION



OHIO RIVER POLLUTION SURVEY
U.S. PUBLIC HEALTH SERVICE
1942

It is extremely difficult to summarize on a broad scale the effectiveness or the amount that pollution is reduced by treatment and other corrective measures applied to industrial wastes. About the only time that this is possible is when actual sampling and gaging records are available both before and after corrective measures are installed. While it would be possible to estimate the reduction in actual treatment plants, this only tells part of the story, as quite often correction of industrial wastes is accomplished through other than treatment methods. A typical example of this is in a cannery, where good housekeeping methods alone may be as effective as limited treatment. On this table, an effort has been made to indicate the number of plants where at least minor corrective measures have been taken, even though these corrective measures were not installed primarily to correct pollution. Just about half of the plants in the Ohio River Basin, as shown in Table 2, practice at least minor corrective measures.

It was our custom during the Ohio River Pollution Survey to estimate industrial waste pollution loads from analytical results collected at sewage treatment works rather than survey the industries individually. The same situation is true in the case of Cincinnati, where a comprehensive sampling and gaging study yielded information on the magnitude of industrial waste pollution loads and saved the necessity of surveying the individual plants.

Where it is possible, one of the best methods of controlling industrial waste pollution is to discharge it to the municipal treatment plant. As shown by table, it is believed that 626 of the total of 1604 industrial plants can be handled in this manner. The percentage which can be discharged safely to municipal treatment depends a good deal on the industry. For example, 37 of the 38 breweries surveyed can be discharged to municipal treatment when treatment plants are available, whereas in the case of the oil refining industry, only 2 of 47 plants can be so discharged, and presumably oil separators would be needed at these two refineries.

Figure 3 shows the location of industrial plants where corrective measures are suggested either by discharge to municipal treatment plants or by independent industrial waste corrective measures. The greatest single industrial plant group shown includes those to be discharged to municipal treatment plants. The locations of plants where independent industrial waste corrective measures are suggested as follows:

Meat: Generally distributed, with most plants in Indiana and Ohio.

Milk: Chiefly Indiana, Ohio and Pennsylvania.

Distillery: Practically all in Kentucky.

Canning: Practically all in Indiana and Ohio, with small plants in Tennessee.

Textile: Practically all in the Tennessee Valley.

Tannery: Eastern edge of basin - Pennsylvania, West Virginia, Virginia and North Carolina.

Paper: Indiana, Ohio, Pennsylvania, Virginia, North Carolina and Tennessee.

Oil: Pennsylvania and scattered.

Steel: Pensylvania, West Virginia, Ohio, and scattered.

Chemical: Chiefly West Virginia.

Coke: Pennsylvania, Ohio and West Virginia.

Miscellaneous: Scattered.

Acid Mine Drainage. Figure 4 shows by means of the areas of circles the acid loads from coal mines prior to the WPA mine-sealing program. The clear segments show the portion of the loads in the various states that has been removed by the WPA mine-sealing program. While these clear areas show the amount of acid reduction as of 1938, they are probably optimistic when considered as a reflection of the present situation, as these mine seals have been given practically no maintenance since 1938 and may in many cases now be ineffective. The shaded areas represent the possible further reduction in acid loads by continuation of the program in accordance with the restrictions imposed on the WPA program. These restrictions were that sealing should be confined to mines where the costs were not greater than $10 per ton of acid discharge per year, and furthermore, sealing was confined to those areas not connected with active ventilation systems. The black areas represent acid loads from active mines and mines which are still connected to active ventilation systems.

The program of mine-sealing as described in the present report was confined to areas not connected to active ventilation systems. Actually, a truly comprehensive mine-sealing program might extend to advantage to all areas except actual active workings.

When we speak of damages caused by pollution, in a great majority of cases it is difficult to place an actual monetary value on these damages. However, in the case of acid mine drainage, substantial and tangible damages can be shown. Table 3 shows an estimate of at least part of the damage created by acid mine drainage in the area above the Pennsylvania-Ohio-West Virginia state line. This table shows that the damages are now over $2,000,000 per year and will soon reach $3,000,000 per year. These evaluated damages can be considered only a part of the total damage, as in the case of other types of pollution, many of the damages are intangible. Also, one of the greatest damages, namely, damage to the mine equipment or to the mines themselves, is not included.

The question of the over-all cost of a pollution abatement program will conclude my remarks, but I have inserted Table 4, which presents some figures on the mine-sealing program only. This indicates that $7,018,000 has been spent by WPA on mine-sealing, of which $5,370,000 was in the Ohio River Basin. To complete a program of mine-sealing with the restrictions I have already described will cost $6,500,000 more, of which $5,500,000 will be in the Ohio River Basin.

The report of the Ohio River Committee recommends that the Bureau of Mines be authorized to complete the $5,500,000 program and further that the Bureau of Mines be authorized to maintain all existing and new mine seals and to conduct further studies, at a cost not to exceed $1,000,000 annually, for a period of 15 years.

Table 3 - Acid Mine Drainage - Summary, as of 1940, of Annual Damages, Capable of Accurate Estimation and Caused by Acid Mine Drainage above the Ohio-West Virginia-Pennsylvania State Line.

		Total Annual Damages
Domestic Water Supplies		$ 364,000
Industrial Water Supplies		407,000
Steamboats and Barges		1,143,000
Power Plants		76,000
River and Harbor Structures		76,000
Floating Plant (U.S.E.D.)		5,000
Total - 1940		2,071,000
Future Estimate - 1950	Based on estimated future quality but no increase in use	2,630,000
Future Estimate - 1960		3,190,000

Table 4 - Cost of Mine-Sealing

Item	Ohio Basin Only	Total Coal Fields
Spent to 1940 by WPA	$ 5,370,000	$ 7,018,000
To complete program with 1940 restrictions (1)	5,510,000	6,500,000
Total	10,880,000	13,518,000
Recommended by Ohio River Committee	5,500,000	
Plus $1,000,000 per year for 15 years	15,000,000	
Total	20,500,000	
Postwar program recommended in 1942 to National Resources Planning Board by E. W. Lyon, Regional Consultant, Office of Mine-Sealing, U. S. P. H. S. (Now Senior Mining Engineer, U. S. Bureau of Mines)		16,000,000
Annual charges 15 per cent (2)		2,400,000
Average annual coal production 1935-1938, net tons (Minerals Year Book - 1938)		400,000,000
Cost per net ton of coal produced		$0.006

(1) Cost limitation of $10.00 per ton of acid per year, and sealing only in areas not connected to active ventilation systems.

(2) Interest 3.5 per cent, Amortization 0.7 per cent (3.4 per cent interest and 50-year life), Inspection 2 per cent, and Maintenance 7 to 10 per cent.

More recently, Mr. E. W. Lyon, formerly the U. S. Public Health Service Regional Consultant in Charge of mine-sealing activities, recommended a postwar plan to the National Resources Planning Board involving an expenditure of $16,000,000. The U. S. Public Health Service has turned the mine-sealing program over to the Bureau of Mines, and Mr. Lyon is now a Senior Mining Engineer with that Bureau, and is continuing his interest in mine-sealing. Annual charges of 15 per cent on this $16,000,000 will be $2,400,000, or, on the basis of an annual coal production from 1935 through 1938 of 400,000,000 net tons of coal mined per year, this will amount to 6 mills per ton. Actually Mr. Lyon had in mind devoting part of the $16,000,000 to maintaining existing and future seals and conducting research work, so that 6 mills per net ton is high as an annual cost figure.

METROPOLITAN AREAS

I have prepared slides showing data on the pollution problems at six metropolitan areas, four, namely Pittsburgh, Huntington-Ironton, Cincinnati and Louisville, on the main Ohio River, and two, Youngstown, Ohio, and Charleston, W. Va., on tributaries.

Pittsburgh, Pa. The area below Pittsburgh extending down to Wheeling is critical, due to the close proximity of water supply intakes to sources of pollution. The water treatment plants in this area have some of the most complex treatment problems possible. Not only is bacterial pollution an ever-present menace, but acids and tastes and odors complicate the problem. The Ohio River Committee recognized this as one of the more urgent situations in the Ohio River Basin and included it as one of the areas which should be given first attention.

Huntington-Ironton Area. The Huntington-Ironton area is on a par with the area below Pittsburgh, in that water supplies are seriously affected by pollution. Not only does the effect of the upper Ohio River pollution reach this area, but pollution from the Kanawha River enters about 40 miles above, and local pollution creates a serious health hazard in these communities. Water treatment problems are due to taste- and odor-producing substances and bacterial pollution.

Cincinnati Area. The Cincinnati area is plagued by taste and odor pollution and bacterial pollution from upstream communities, and in turn plagues itself and downstream stretches of the river with its pollution. Fortunately for Cincinnati, there are no sources of pollution of any great magnitude for some distance above the city. As a result, during normal times, particularly in warm weather, natural purification agencies have a chance to protect the city's water supply, both from bacterial pollution and taste and odor pollution. During the winter months, when rates of purification are lower, Cincinnati is confronted with serious taste and odor problems.

When the river is moderately high, the time of flow between points of pollution and Cincinnati is greatly reduced and bacterial pollution is of consequence. As far as Cincinnati is concerned, the worst situation occurs during the winter months when a rise in the river follows a long period of low flow. During a period of low flow, pollution accumulates in the upper pools of the river, and with a rise in the river this accumulation of pollution is carried down to Cincinnati in a relatively short time. The highly efficient water purification plant at Cincinnati has been unsuccessful at numerous times in removing

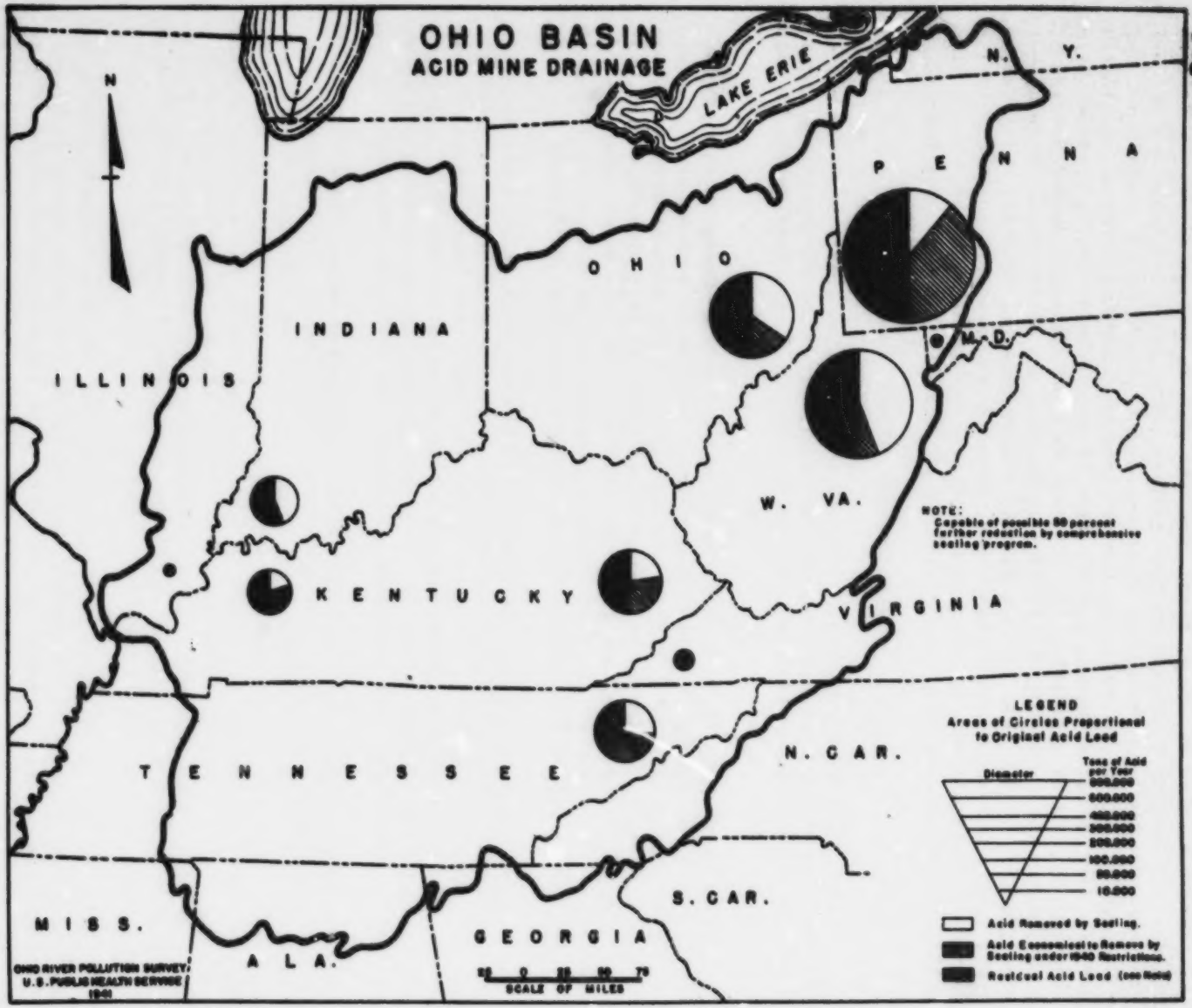

OHIO BASIN
ACID MINE DRAINAGE
LAKE ERIE
N. Y.
PENNA
OHIO
INDIANA
ILLINOIS
W. VA.
KENTUCKY
VIRGINIA
TENNESSEE
N. CAR.
S. CAR.
GEORGIA
MISS.
ALA.
M. D.
N
NOTE:
Capable of possible 50 percent further reduction by comprehensive sealing program.
LEGEND
Areas of Circles Proportional to Original Acid Load
Diameter
Tons of Acid per Year
Acid Removed by Sealing.
Acid Economical to Remove by Sealing under 1940 Restrictions.
Residual Acid Load (000 Tons)
SCALE OF MILES
OHIO RIVER POLLUTION SURVEY
U.S. PUBLIC HEALTH SERVICE
1941

Fig. 4

tastes and odors. In addition, as in the cases below Pittsburgh and the Huntington-Ironton area, the bacterial pollution load exceeds that which can be used in the modern water treatment plant to produce a safe drinking water.

Cincinnati extends for a distance of 20 miles along the Ohio River, and the effects of pollution are apparent in the river opposite the city. Some of the lowest dissolved oxygen results on the main Ohio River were obtained opposite and immediately below the city. The bacterial pollution detrimentally affects the public water supply of Louisville, but worse than that, does great damage to the water supply at the little town of Aurora, some 20 miles below the city.

Louisville. From a water supply standpoint, Louisville's problems are similar to those at Cincinnati, in that during normal times the river has recovered to a large degree from the effects of the pollution from Cincinnati and upstream communities. As at Cincinnati, tastes and odors are frequent experiences and the water plant has been unsuccessful in delivering a satisfactory water. The sewage and industrial wastes cause an oxygen sag somewhat smaller than below Cincinnati, and the water supply of New Albany is jeopardized by pollution from the city.

Youngstown, Ohio. The Mahoning River in the vicinity of Youngstown, Ohio, is one of the most highly polluted streams in the Ohio River Basin. Not only are there large sources of sewage and industrial waste pollution being discharged without treatment, but the water is used to such an extent for cooling water that the temperature increases tend to pyramid, resulting in increased biological activity, and decreasing the ability of the river to maintain dissolved oxygen. The use of such water for cooling purposes, particularly in plate mills, creates extremely noxious odors. The river itself is a nuisance during the summer months through the congested area. In addition, the pollution has an extremely detrimental effect on lower water supplies, particularly those on the Beaver River.

At such time as sewage treatment and industrial waste corrective measures are installed in the Youngstown district, the use of increased low flows will be of considerable assistance in improving the quality of both the Mahoning and Beaver Rivers as a supplement to other corrective measures. This will be discussed later in connection with the general possibilities of assisting pollution problems through the use of reservoirs.

Charleston, W. Va. Some of the largest individual sources of pollution in the Ohio River Basin are located on the Kanawha River, from Belle, about 70 miles from the mouth, to the mouth. These pollution loads are largely from the chemical plants of the area, and domestic sewage is a relatively minor influence. The expansion that has taken place in this area during the war has resulted in increased pollution loads, and the Ohio River Pollution Survey Report already is out of date for the Kanawha River. Two small water supplies on the lower Kanawha River have a tremendous problem and Ohio River water supplies report increasing troubles due to tastes and odors which may be attributed, at least in part, to Kanawha River pollution. The West Virginia State Health Department and State Water Commission are co-operating with the industries in the area in an effort to solve the many problems involved. Because of the technical and often secret nature of industrial processes, corrective measures are squarely up to the industries themselves.

LOW-FLOW REGULATION

The seriousness of a pollution problem depends on the relationship between the magnitude of pollution loads and the magnitude of minimum flows in the outlet watercourse. Thus pollution conditions can be improved on the one hand by decreasing the magnitude of pollution loads and on the other hand by increasing the quantity of dilution water available. Figure 5 shows existing and proposed major reservoirs in the Ohio Basin. While increased low flows are in no sense a substitute for sewage and industrial waste treatment or other corrective measures, increased low flows can be of considerable assistance in completing a pollution abatement activity in cases where the limit of treatment processes available is insufficient to reclaim a stream, and in other cases increased low flows will reduce the cost of treatment.

Increased low flows in many cases will accomplish results which are not possible by sewage and industrial waste treatment methods. During the survey, for example, one of the most efficient treatment plants in the country was in operation at Columbus, Ohio. However, at times there was no flow in the Scioto River opposite Columbus, and despite the high degree of treatment available, conditions were not satisfactory below the city. This is one case where increased low flow would accomplish results not possible by treatment methods. The situation is worse today, as Columbus has outgrown its efficient treatment plant.

In cases where increased low flow might reduce the cost of sewage treatment, such a reduction might not actually be realized, a high degree of treatment being installed despite the increased flow, and the increased flow being used to raise the objective of the pollution abatement program, again making improvements which would not be possible with treatment alone. There is a danger that installation of reservoirs for the increase of low flow will alleviate conditions to some extent and relieve the pressure for the installation of treatment plants. In order to guard against such a contingency, it is possible to designate pollution abatement benefits as contingent upon local participation in a stream clean-up program through the installation of local treatment works. In this case the possibility of reservoir construction is used to add and incentive for the installation of a treatment plant.

In the Ohio River Basin, floods have a markedly seasonal character, and low flows have an equally seasonal character. For example, flood damage is at a maximum in March, decreases greatly after the middle of April, and from May to September is of minor consequence. In operating a flood control reservoir, therefore, it is possible to maintain flood control storage unimpaired until about the middle of April, using high flows between that time and the low-flow season later in the summer to partially fill the flood control reservoir, leaving a lesser flood capacity for protecti against the lesser possibility of summer floods. This method of operation of flood control reservoirs has been carefully studied by the Corps of Engineers and methods of operation have been designed to secure a maximum increase in low flow with a minimum of effect on flood protection.

On all proposed reservoirs, the Corps of Engineers include a careful consideration of the possibilities of low-flow regulation in connection with reservoir studies. Through an agreement between the Chief of Engineers, War Department, and the Surgeon General, U.S. Public Health Service, the Cincinnati Station is assisting in these studies by estimating the magnitude of useful flows and the monetary benefits resulting from increased flows. This agreement covers not

OHIO BASIN
MAJOR RESERVOIRS
CHICAGO
SOUTH BEND
TOLEDO
CLEVELAND
FORT WAYNE
Peoria
Springfield
ILLINOIS
INDIANA
Kokomo
Muncie
INDIANAPOLIS
Terre Haute
COLUMBUS
DAYTON
CINCINNATI
Portsmouth
ST. LOURS
Vincennes
LOUISVILLE
Frankfort
Lexington
EVANSVILLE
Hurrisburg
KENTUCKY
Cairo
MO.
Clarksville
NASHVILLE
Columbia
TENNESSEE
KNOXVILLE
Johnson City
Kingsport
Bristol
Harlan
MEMPHIS
Florence
Huntsville
Decatur
Gadsden
MISS.
ALA.
GEORGIA
S.
OHIO RIVER POLLUTION SURVEY
U. S. PUBLIC HEALTH SERVICE
MARCH 1942
SCALE OF MILES

RESERVOIRS COMPLETED OR UNDER CONSTRUCTION

— LEGEND

No.	Name	Major Purposes	Ownership	Capacity Acre-Feet
1	Tionesta	F	F	125,800
2	Piney	P	P	28,200
3	Mahoning Cr.	F	F	98,800
4	Crooked Cr.	F	F	88,300
5	Loyalhanna	F	F	93,500
6	Quemahoning	I	P	31,800
7	Youghiogheny	FA	F	249,000
8	Deep Cr.	P	P	108,000
9	Lake Lynn	P	P	72,300
10	Tygart	FN	F	278,800
11	Pymatuning	FIA	S	197,000
12	Meander Cr.	M	D	32,400
13	Milton	IA	M	23,000
14	Berlin	FIA	F	71,000
15	Atwood	F	F	49,700
16	Beach City	F	F	71,700
17	Bolivar	F	F	149,800
18	Charles Mill	F	F	88,000
19	Clendenin	F	F	54,000
20	Dover	F	F	203,000
21	Leesville	F	F	37,400
22	Mohawk	F	F	285,000
23	Mohicanville	F	F	102,000
24	Piedmont	F	F	65,000
25	Pleasant Hill	F	F	87,700
26	Senecaville	F	F	88,500
27	Tappan	F	F	61,800
28	Wills Cr.	F	F	196,000
29	Bluestone	FP	F	609,400
30	Claytor	P	P	225,000
31	O'Shaughnessy	M	M	18,400
32	Germantown	F	D	106,000
33	Englewood	F	D	312,000
34	Taylorsville	F	D	186,000
35	Huffman	F	D	167,000
36	Loramie	F	D	70,000
37	Dix	P	P	300,000
38	Wolf Cr.	FP	F	5,782,000
39	Dale Hollow	FP	F	1,838,000
40	Center Hill	FP	F	2,032,000
41	Great Falls	P	F	54,500
42	Kentucky	NFP	F	6,100,000
43	Pickwick Landing	NFP	F	1,091,000
44	Wilson	NP	F	535,000
45	Wheeler	NFP	F	1,150,000
46	Guntersville	NFP	F	1,018,700
47	Hales Bar	NP	F	128,800
48	Chickamauga	NFP	F	705,000
49	Watts Bar	NFP	F	1,132,000
50	Ft. Loudon	NFP	F	365,500
51	Norris	FP	F	2,567,000
52	Apalachia	P	F	50,000
53	Hiwassee No.1	FP	F	438,000
54	Ocoee	P	P	76,800
55	Blue Ridge	P	F	197,500
56	Nottely	P	F	190,000
57	Chatuge	P	F	240,000
58	Calderwood	P	P	34,000
59	Cheoah	P	P	31,000
60	Fontana	FP	F	1,300,000

RESERVOIRS COMPLETED OR UNDER CONSTRUCTION — LEGEND

No.	Name	Major Purposes	Ownership	Capacity Acre-Feet
1	Tionesta	F	F	125,800
2	Piney	P	P	28,200
3	Mahoning Cr.	F	F	98,500
4	Crooked Cr.	F	F	88,500
5	Loyalhanna	F	F	93,500
6	Quemahoning	I	P	31,800
7	Youghiogheny	FA	F	249,000
8	Deep Cr.	P	P	106,000
9	Lake Lynn	P	P	72,300
10	Tygart	FN	F	276,800
11	Pymatuning	FIA	S	197,000
12	Meander Cr.	M	D	32,400
13	Milton	IA	M	23,000
14	Berlin	FIA	F	71,000
15	Atwood	F	F	49,700
16	Beach City	F	F	71,700
17	Bolivar	F	F	149,600
18	Charles Mill	F	F	88,000
19	Clendenin	F	F	54,000
20	Dover	F	F	203,000
21	Leesville	F	F	37,400
22	Mohawk	F	F	285,000
23	Mohicanville	F	F	102,000
24	Piedmont	F	F	65,000
25	Pleasant Hill	F	F	87,700
26	Senecaville	F	F	88,500
27	Toppan	F	F	61,800
28	Wills Cr.	F	F	196,000
29	Bluestone	FP	F	608,400
30	Clayton	P	P	225,000
31	O'Shaughnessy	M	M	16,400
32	Germantown	F	D	106,000
33	Englewood	F	D	312,000
34	Taylorsville	F	D	188,000
35	Huffman	F	D	187,000
36	Loramie	F	D	70,000
37	Dix	P	P	300,000
38	Wolf Cr.	FP	F	5,782,000
39	Dale Hollow	FP	F	1,838,000
40	Center Hill	FP	F	2,032,000
41	Great Falls	P	F	54,900
42	Kentucky	NFP	F	6,100,000
43	Pickwick Landing	NFP	F	1,091,000
44	Wilson	NP	F	536,000
45	Wheeler	NFP	F	1,130,000
46	Guntersville	NFP	F	1,018,700
47	Hales Bar	NP	F	128,800
48	Chickamauga	NFP	F	708,000
49	Watts Bar	NFP	F	1,132,000
50	Ft. Loudon	NFP	F	365,500
51	Norris	FP	F	2,567,000
52	Apalachia	P	F	50,000
53	Hiwassee No.1	FP	F	438,000
54	Ocoee	P	F	76,800
55	Blue Ridge	P	F	197,500
56	Nottely	P	F	190,000
57	Chatuge	P	F	240,000
58	Calderwood	P	P	34,000
59	Cheoah	P	P	31,000
60	Fontana	FP	F	1,800,000

Continued

No.	Name	Major Purposes	Ownership	Capacity Acre-Feet
61	Santeetlah	P	P	156,000
62	Nantahala	P	P	140,000
63	Glenville	P	P	71,000
64	Cherokee	P	F	1,840,000
65	S. Holston	P	F	680,000
66	Watauga	P	F	627,000
67	Douglas	P	F	1,280,000
68	Waterville	P	P	25,000
69	Nolichucky	P	P	

LEGEND

Major Purposes	Ownership
F — Flood Control	F — Federal
P — Power	S — State
M — Municipal W.S.	M — Municipal
I — Industrial W.S.	D — Public District
N — Navigation	P — Private
A — Pollution Abatement	

PROPOSED FLOOD-CONTROL AND MULTIPLE-PURPOSE RESERVOIRS IN OHIO VALLEY FLOOD CONTROL PLAN — LEGEND

70	Allegheny	97	Delaware
71	French Creek	98	Big Darby
72	Red Bank Creek	99	Deer Creek
73	Conemaugh	100	Paint Creek
74	West Fork	101	Rocky Fork
75	Shenango	102	Caesar Creek
76	Mosquito Creek	103	East Fork
77	Eagle Creek	104	Falmouth
78	Millersburg	105	Cove Run
79	Frazeysburg	106	Metamora
80	Dillon	107	Brookville
81	Burnsville	108	Buckhorn
82	Steer Cr.	109	Beaneville
83	West Fork	110	Jessamine Creek
84	Logan	111	Rough River
85	Pace	112	Mining City
86	Birch	113	Nolin River
87	Clendenin	114	No.2 Barren
88	Summersville	115	No.2 Green
89	Big Bend	116	Mansfield
90	Moores Ferry	117	Eagles Mill
91	Mud River	118	Spencer
92	East Lynn	119	Shoals
93	Dewey	120	Wolf Creek
94	Fishtrap	121	Rossview
95	Clintwood	122	Three Islands
96	Hazel	123	Stewarts Ferry

Fig. 5

OHIO BASIN
MAJOR RESERVOIRS

only the Ohio River Basin where some 20 studies have been made, but also other river basins throughout the country, notable among which are the Missouri and Potomac River Basins. Benefits are estimated from the reduction in cost of sewage and industrial waste treatment. Results may be accomplished in excess of those possible by treatment methods, and benefit estimates are to be considered conservative.

Locations in the Ohio River Basin where low flow can be used to advantage include the main Ohio River, where benefits will accrue throughout the full length of the stream. On the tributaries, increased low flows can be used to advantage on the Allegheny and Monongahela Rivers in Pennsylvania, the Mahoning, Scioto and Miami Rivers in Ohio, the Kanawha River in West Virginia, and the West Fork of White River in Indiana. Increased low flows will have lesser benefits on a great many other tributaries in the Ohio River Basin. The benefits from increased low flows on the Mahoning River are particularly outstanding, in that not only is the pollution problem benefited through an increase in the dilution water available, but is also benefited through a reduction in the water temperature, thus reducing the quantity of water required.

Generally speaking, reservoir construction is too expensive to be justified by the benefits from pollution abatement alone. However, in many cases, pollution abatement benefits can be added to flood control, power, navigation and other benefits to improve the economic ratio of benefits to cost to a sufficient degree to justify a project which might not ohherwise be justified.

COST OF POLLUTION ABATEMENT

Table 5 presents a summary of the costs of pollution abatement in the Ohio River Basin, particularly for those states contemplated as parties to the Ohio River Valley Water Sanitation Compact. The first thing probably noted is that Pennsylvania is confronted with the greatest bill, which constitutes 27.2 per cent of the total. Ohio is next with a bill of 21.8 per cent of the total. However, it is noted that if costs to date are considered, the total bill for Pennsylvania is $57,200,000, while the total bill for Ohio is $71,400,000, or some $14,000,000 greater than Pennsylvania.

The cost estimates cover a complete pollution abatement program in so far as it is possible to recommend specific corrective measures at the present time. It is not therefore an ultimate program. In the case of certain industries, notably the chemical and paper pulp industries, there is some question as to the exact corrective measure to be applied and in this particular instance it is not possible to recommend specific steps to take. A cost estimate in such instances is not included. In correcting pollution from industrial wastes, it is almost always necessary to segregate strong wastes and specific types of wastes for special handling. This involves a rearrangement of the sewer systems within the plant in order to bring wastes of a specific type to one point for treatment. A typical example is the cost of rearranging sewers in a by-product coke plant in order to treat phenol-containing wastes by a recovery system. In a survey of the magnitude of the present one, it is not possible to prepare accurate estimates for rearranging plant sewers and this item is not included. In the case of acid mine drainage, a rather large program is possible if an attempt is made to expand the program into mined-out sections of active mines. Here again some study may be required, not only to determine the exact procedure to be followed but also

Table 5 - Pollution Abatement Capital Costs - Ohio River Valley

(Costs, in Thousands of Dollars as of 1928 to 1940)

State	Cost to Date			Estimated future costs (1)					Total cost, to date and future	Per cent completed
	Municipal	Mine Drainage	Total	Municipal	Industrial	Mine Drainage	Total	Per cent of Valley total		
Illinois	3,760	Minor	3,760	2,470	20	0	2,490	1.4	6,250	60
Indiana	14,990	270	15,260	17,910	1,830	80	19,820	11.0	35,080	44
Kentucky	4,585	340	4,925	17,140	1,010	1,200	19,350	10.8	24,275	20
New York	4,260	0	4,260	540	90	0	630	.3	4,890	87
Ohio	30,380	1,940	32,320	35,240	3,440	400	39,080	21.8	71,400	45
Pennsylvania	6,940	1,490	8,430	43,050	2,620	3,100	48,770	27.2	57,200	15
Tennessee	2,900	110	3,010	21,670	1,090	420	23,180	12.9	26,190	11
Virginia	380	0	380	1,880	160	150	2,190	1.2	2,570	15
West Virginia	1,495	1,210	2,705	14,600	2,570	160	17,330	9.7	20,035	14
Other (2)	500	10	510	5,840	750	0	6,590	3.7	7,100	7
Total	70,190	5,370	75,560	160,340	13,580	5,510	179,430	100.0	254,990	30

(1) Costs in 1942 had increased 32 per cent.

(2) Alabama, Georgia, Maryland, Mississippi, North Carolina.

to arrive at a reliable estimate of cost. The mine-sealing program as recommended includes only that part which we know can be completed with a minimum of preliminary study.

In preparing a suggested program, it was the object of the U. S. Public Health Service to outline a program which could actually be followed and carried through and not have part of the program contingent upon time-consuming preliminary investigations of methods to be used.

CONCLUSION

Of all the sections of the report "Ohio River Pollution Control" probably the most interesting to the present gathering has to do with the recommendations of the Ohio River Committee. It is presumed that the delegates assembled will give these recommendations a separate discussion. There is one recommendation of the Ohio Committee, however, that I would like to read to this gathering. Paragraph 208 (c) recommends "That the proposed Ohio River Valley Water Sanitation Compact take control of all existing and future sources of pollution, including acid drainage from mines other than that specifically recommended for correction by the Federal Government, affecting the normal use of water in another State."

The report I have discussed is a printed document. It describes conditions as of 1940 and it is fixed and finished. On the other hand, sources of pollution and river water quality are constantly changing. In general, the pollution picture presented describes the present situation. However, many parts of the report are already out of date. The report can serve its purpose of furnishing a starting point. What is needed, however, is a permanent organization with a continuing program. Eternal vigilance is necessary if pollution abatement progress is to be made. The Ohio River Committee, in words I have just read, has recommended that the permanent organization be the Ohio River Valley Water Sanitation Compact.